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ANALYSIS AND CHARACTERIZATION OF GaN BASED MATERIALS AND DEVICES

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We calculated the elastic strain relaxation in wurtzite GaN-A1N-GaN semiconductor-insulator-semiconductor (SIS structures, Elastic strain tensor components, elastic energy, the density of the misfit dislocations, and the other parameters of the system were obtained as functions of the A1N layer thickness. Theoretical values of the elastic strain relaxation are in satisfactory agreement with experimental data extracted from capacitance-voltage characteristics of GaN-A1N-Gun SIS structures.

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We calculated the elastic strain relaxation in wurtzite GaN-AlN-GaN semiconductor-insulator-semiconductor (SIS) structures.[1] Elastic strain tensor components, elastic energy, the density of the misfit dislocations, and the other parameters of the system were obtained as functions of the AlN layer thickness. Theoretical values of the elastic strain relaxation are in satisfactory agreement with experimental data extracted from the capacitance-voltage (C-V) characteristics of GaN-AlN-GaN SIS structures.[2] The calculated value of the starting point for the generation of dislocations is in agreement both with our experimental data and with the data[3] obtained for GaN/AlN superlattices.

In Fig. 1, we plotted the relative deformation along the interface as a function of L calculated by considering the minimum of the energy of the system.[1]

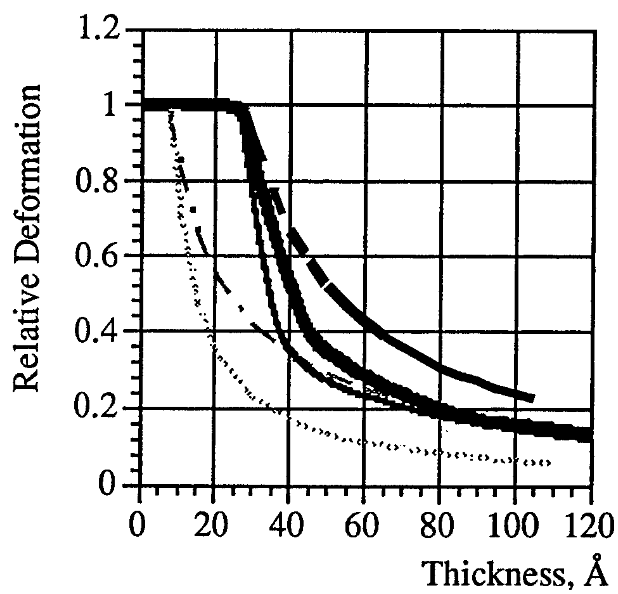

Fig. 1. Relative deformation along the interface as a function of AlN film thickness.
Calculations: three $<11\bar{2}0>$ slip systems (thick solid line), two slip systems in the perpendicular directions (thin solid line), Ref. 5 (dashed-dotted line), Ref. 4 (dotted line). The experimental data extracted from the capacitance-voltage measurements (dashed line).

In this figure, we presented our theoretical results for the SIS structure with three

[1] A. D. Bykhovski, B. L. Gelmont, and M. S. Shur. Elastic Strain Relaxation in GaN-AlN-GaN Semiconductor-Insulator-Semiconductor Structures, J. Appl. Phys., 1 September 1995, to be published.
[2] A. Bykhovski, B. Gelmont, M. Shur, and A. Khan, Inst. Phys. Conf. Ser. No 137: Chapter 7, 691 (1994).
[3] Z. Sitar, M. J. Paisley, B. Yan, J. Ruan, W. J. Choyke, and R. F. Davis, J. Vac. Sci. Technol. B 8 , 316 (1990).

slip systems along the $<11\bar{2}0>$ directions, and for a structure having two slip systems in the perpendicular directions. We also showed in Fig. 1 the experimental data extracted from the capacitance-voltage measurements. [2] Finally, for comparison, we plotted the results for an overlayer on the infinite substrate obtained in [4,5]. Ref. [5], predicts too strong a relaxation in thinner (up to 50 Å thick) AlN films (see Fig. 1). It predicts a starting point for the generation of dislocations at L = 5 - 7.5 Å (2-3 monolayers) which is clearly too small.[2, 3] More precise calculations for an overlayer on the infinite substrate made in [4] gives even a larger overestimation of the relaxation process. As it can be seen from Fig. 1, our approach gives the best fit to the experimental data, if the hexagonal slip systems are taken into account.

Our results confirm that the gradual relaxation process starts from 30 Å AlN film thickness. The uniform contributions to the elastic strain tensor components decrease by approximately an order of magnitude when the film thickness increases from 30 Å to 100 Å. Commensurate with this decrease is an increase in a non-uniform contribution of the misfit dislocations. The dislocation interactions lead to redistribution of dislocations within 30 Å - 60 Å range of AlN film thicknesses.[1]

[4]J. H. van der Merwe, J. Appl. Phys., 34, 123 (1963).
[5]J. W. Matthews, J. Vac. Sci. Technol., 12, 126 (1975).

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